HIGH PERFORMANCE SCHOOLS: SEIZING THE BUILT COMMUNITY'S TEACHABLE MOMENT

ABX: October 29, 2014

CONTINUING EDUCATION

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PRESENTATION SUMMARY

1. Northeast Collaborative for High Performance Schools

Brian Buckley, Northeast Energy Efficiency Partnerships
High Performance Buildings Associate

2. Case Study: Claiborne Pell Elementary

Matt LaRue, HMFH Architects
Architect, Claiborne Pell Elementary

3. Case Study: East Bay Met School

Chris Armstrong, Steven Turner Inc.
Commissioning Agent, East Bay Met School

NORTHEAST ENERGY EFFICIENCY PARTNERSHIPS

"Accelerating Energy Efficiency"

MISSION

Accelerate the efficient use of energy in the Northeast and Mid-Atlantic Regions

APPROACH

Overcome barriers to efficiency through ***Collaboration*, *Education & Advocacy***

VISION

Transform the way we think about and use energy in the world around us.

One of six Regional Energy Efficiency Organizations (REEOs) designated by U.S. Dept. of Energy to work collaboratively with them in linking regions to DOE guidance, products

NORTHEAST COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS (NE-CHPS)

1. Background
    a. What is it?
    b. History
    c. In the Region
    d. Why is it different?
2. The Criteria
    a. Metrics and Examples
    b. Points and Emphasis
    c. Prerequisites
    d. Updated NE-CHPS v. 3.0
3. Exemplars
4. Next Steps
    a. Save the Date- November 5th
    b. NEEP Resources
    c. DOE Resources

BACKGROUND: WHAT IS NE-CHPS?

- NE-CHPS criteria is a **points based new construction/renovation roadmap** toward healthier, more efficient, and more productive schools

- For all schools from pre-K through community colleges.

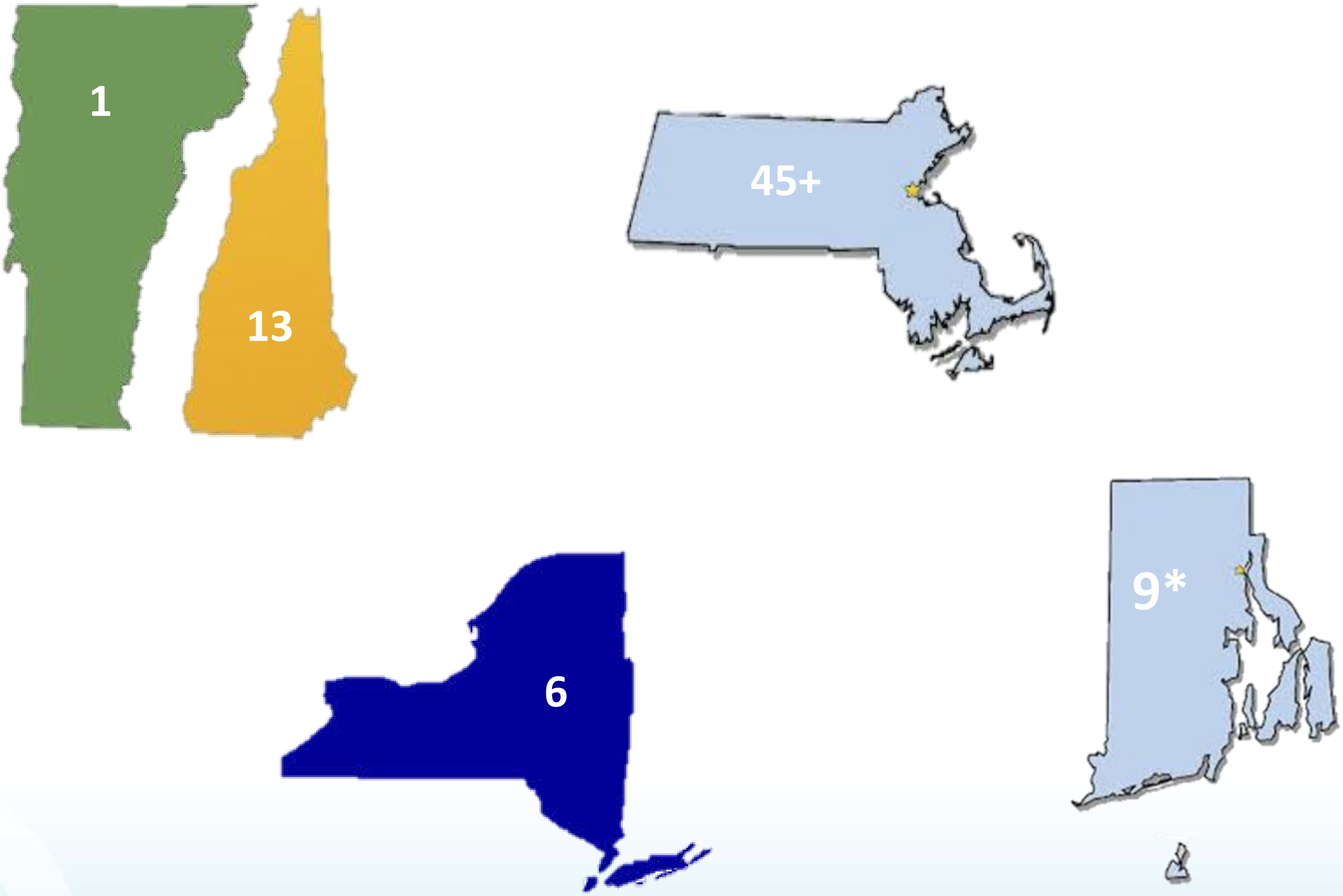
- Stresses an integrated design process, indoor environmental quality, energy efficiency and building operation and maintenance practices that enable high performance without high costs

NORTHEAST COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS
CHPS

BACKGROUND: HISTORY OF CHPS CRITERIA

- First version released in California in 2002
- CHPS Criteria versions cover 13 states
- CHPS National Core Criteria developed 2009-2013
- US CHPS released last week for districts looking to adopt CHPS

BACKGROUND: CHPS IN THE REGION



BACKGROUND: WHY IS NE-CHPS DIFFERENT?

1. **Developed with input from regional stakeholders**
   - Working group of state actors and industry professionals

2. **Reflects the climate, building codes, and educational priorities of the Northeast**
   - Adopted and adapted throughout the Northeast

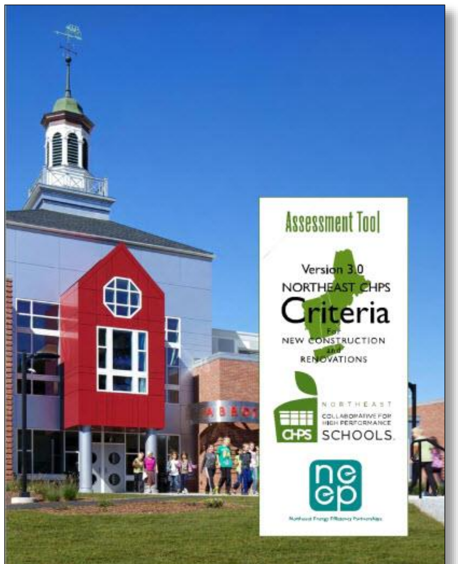
3. **Emphasizes best practices for ongoing building operation and maintenance**
   - Includes companion Operation and Maintenance guide

4. **Stresses Indoor Environmental Quality and Energy Efficient Design**
   - 40+ pages discussing energy efficient design
   - 70+ pages discussing indoor environmental quality and

THE CRITERIA: METRICS AND EXAMPLES

Seven Basic Metrics	Related Example
1. Integrated Design Process	Engineers consult with teachers & students
2. Indoor Environmental Quality	Walk-off mats keep pollutants outside
3. Energy Usage	Photosensor activated lighting
4. Water Usage	Low-flow toilets & waterless urinals
5. Site Selection/Development	Facility located near public transportation
6. Materials & Waste Management	Locally produced materials
7. Operations & Metrics	Occupant behavior seminars

THE CRITERIA: POINTS AND EMPHASIS



Project Type	Required Points
Major Renovations	85
New Construction	110

Criteria	Prerequisite Points	Total Points Possible
Integration and Innovation	6	21
Operations and Metrics	12	23
Indoor Environmental Quality	27	76
Energy	13	68
Water	6	21
Sites	4	22
Materials & Waste Management	4	19
TOTALS	72	250

THE CRITERIA: PREREQUISITES

Integration and Innovation
- Integrated Design
- Educational Display
- Crime Prevention through Environmental Design

Materials and Waste Management
- Storage and Collection of Recyclables
- Minimum Construction Site Waste Management

Indoor Environmental Quality
- HVAC Designed to ASHRAE 62.1
- Outdoor Moisture Management
- Low Emitting Materials
- Daylighting: Glare Protection
- Views
- Acoustic Performance (35 dBA)
- Pollutant and Chemical Source Control

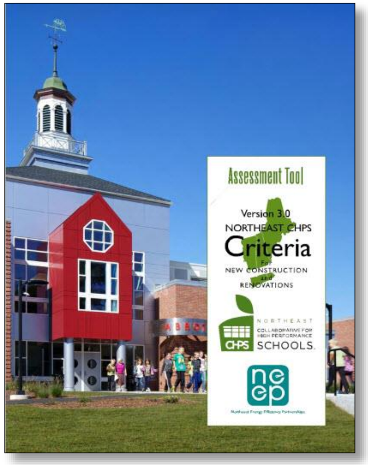
Energy
- Energy Performance (IECC 2012+10%/ NBI)
- Commissioning
- Environmentally Preferable Refrigerants
- Local Energy Efficiency Incentive & Assistance

Operations and Metrics
- Facility, Staff, and Occupant Training
- Performance Benchmarking
- Indoor Environmental Management Plan
- Integrated Pest Management
- Anti-Idling Measures
- ENERGY STAR Equipment and Appliances
- System Maintenance Plan

Sites
- Site Selection
- Site and Building Best Practices

THE CRITERIA: THE LATEST UPDATE, VERSION 3.0

New to NE-CHPS 3.0:



- Improved Acoustics Requirements
- Electric Vehicles
- zEPI Energy Scale
- Benchmarking Emphasis
- Greater Occupant Engagement Focus
- Enhanced Commissioning of Building Systems
- District Level Commitment to Sustainability
- Crime Prevention through Environmental Design

MASSACHUSETTS
HIGH PERFORMANCE SCHOOL EXEMPLARS

1. Freeman Kennedy School
2. Sherwood Middle School
3. Rochester Memorial Elementary School

1. FREEMAN KENNEDY SCHOOL

NORFOLK, MASSACHUSETTS

General Info

- Students: 575
- Size: 96,410 sq. ft
- Cost: ~$26 million

Energy Usage reduced by 45% from baseline

High Performance Attributes:

•50kW PV solar array with real-time monitoring kiosk

•Designed to reduce potable water use by 20%

•90% of non-hazardous construction debris was reused

2. SHERWOOD MIDDLE SCHOOL

SHREWSBURY, MASSACHUSETTS

General Info:

- Students: 900
- Size: 130,000 sq. ft
- Cost: ~$40 million

High Performance Attributes:

- Insulated composite backup panels for superior building envelope construction
- Ducted fresh air intakes optimize indoor air quality
- Automated energy management system

3. ROCHESTER MEMORIAL ELEMENTARY SCHOOL

ROCHESTER, MASSACHUSETTS

General Info:

- Students: 604
- Size: 75,000 sq. ft renovation
  - 34,385 sq. ft new addition
- Cost: ~$17.5 million

Energy Usage reduced by 35.5%

High Performance Attributes:

- Designed for joint use by community, using the school as a teaching tool
- Vegetation requires no permanent irrigation
- Full Wireless building controls

NEXT STEPS: RI NE-CHPS EVENT DEC. 5th

Northeast Energy Efficiency Partnerships

2020 RHODE ISLAND DEPARTMENT OF EDUCATION SCHOOL CONSTRUCTION PROGRAM

On behalf of the Rhode Island Schools Working Group
NEEP and the Rhode Island Department of Education invite you to

ENVISIONING THE FUTURE OF RHODE ISLAND SCHOOL HOUSES: NE-CHPS 3.0 UPDATE

December 5, 2014 - The East Bay Met School - Newport, RI

Did you know that Rhode Island's school construction and renovation criteria—NE-CHPS—was recently updated? Come learn about the latest updates and more at this December workshop. Wrap up the day with an optional tour of the nearby Pell Elementary School.

What: A forum for school construction stakeholders to come together to shape ideas and projects

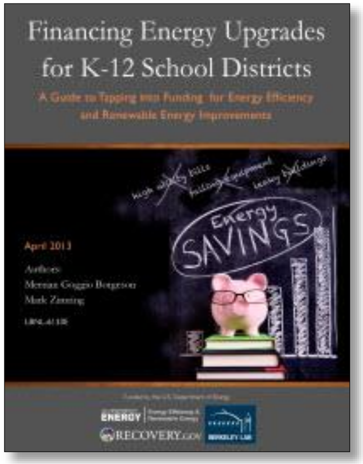
Who Should Attend: Architects, contractors, school superintendents, business managers, and others with an interest in Rhode Island School Construction

Visit www.neep.org/events/ri_chps to register

NEXT STEPS: US DOE RESOURCES

1. Recent Energy-Focused TedEd
    - Joshua Sneideman's "A Guide to the Energy of the Earth"

2. Guide to financing Energy Upgrades for K-12 School Districts
    - Tax Exempt Lease Purchasing
    - Energy Performance Contracting
    - On-Bill Financing
    - Power Purchase Agreements
    - Grants/Internal Cash
    - Bonding



3. Better Buildings Challenge
    - Education Partners
        - Ex. NY's Indian River Central School District
    - Summit May 27-29,2015
        - K-12 Track

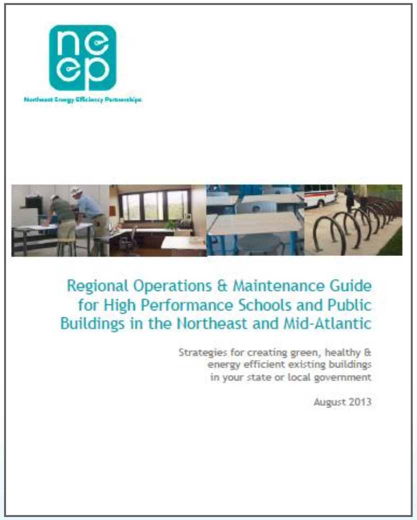
NEXT STEPS: NEEP RESOURCES

For further info:

- Visit the NEEP's NE-CHPS website
- Access the latest version of NE-CHPS
- Check out the Public Buildings Operation & Maintenance Guide
- Contact:
  Brian Buckley at bbuckley@neep.org
  Carolyn Sarno at Csarno@Neep.org

NORTHEAST COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS

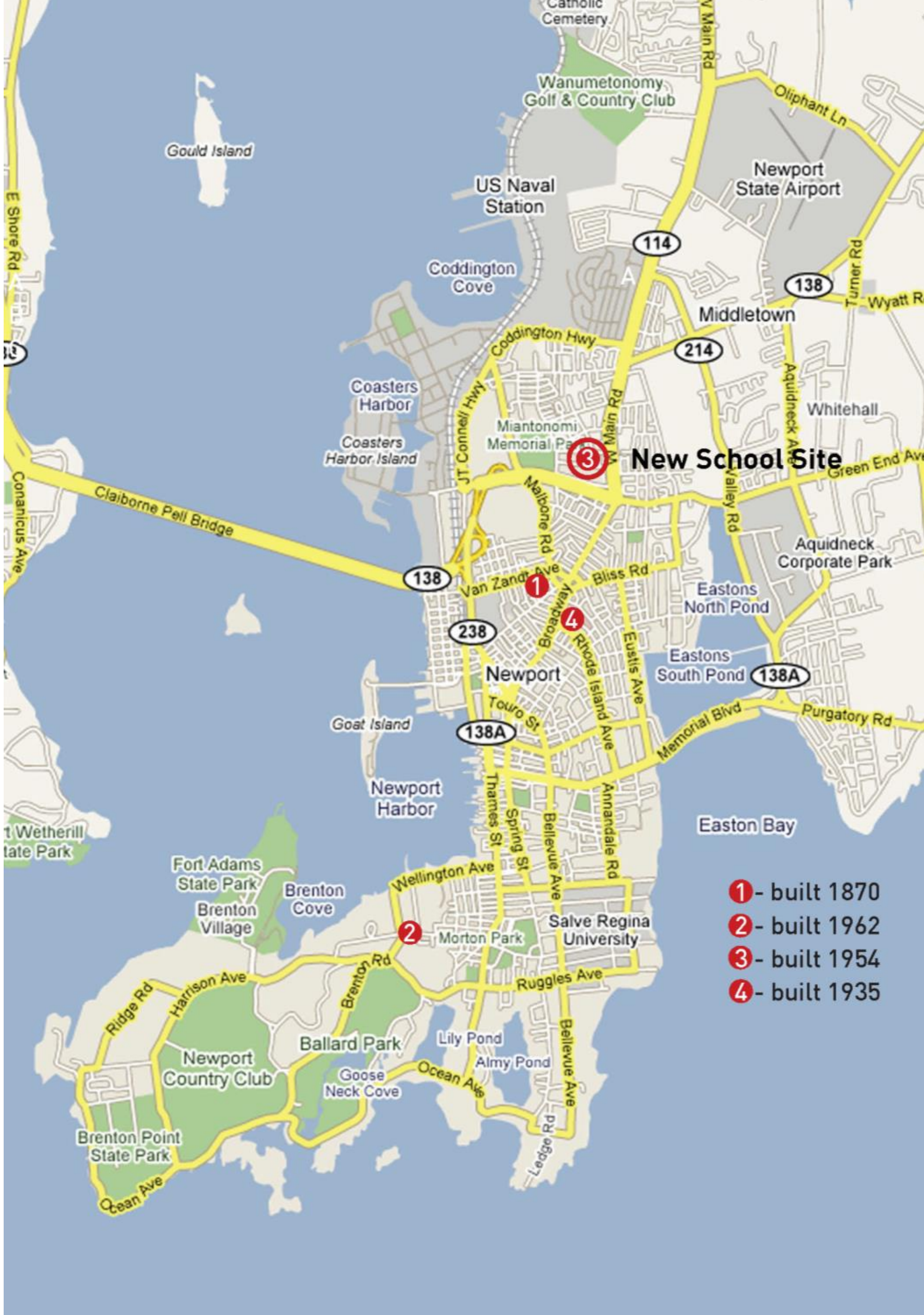
Better buildings. Better students.

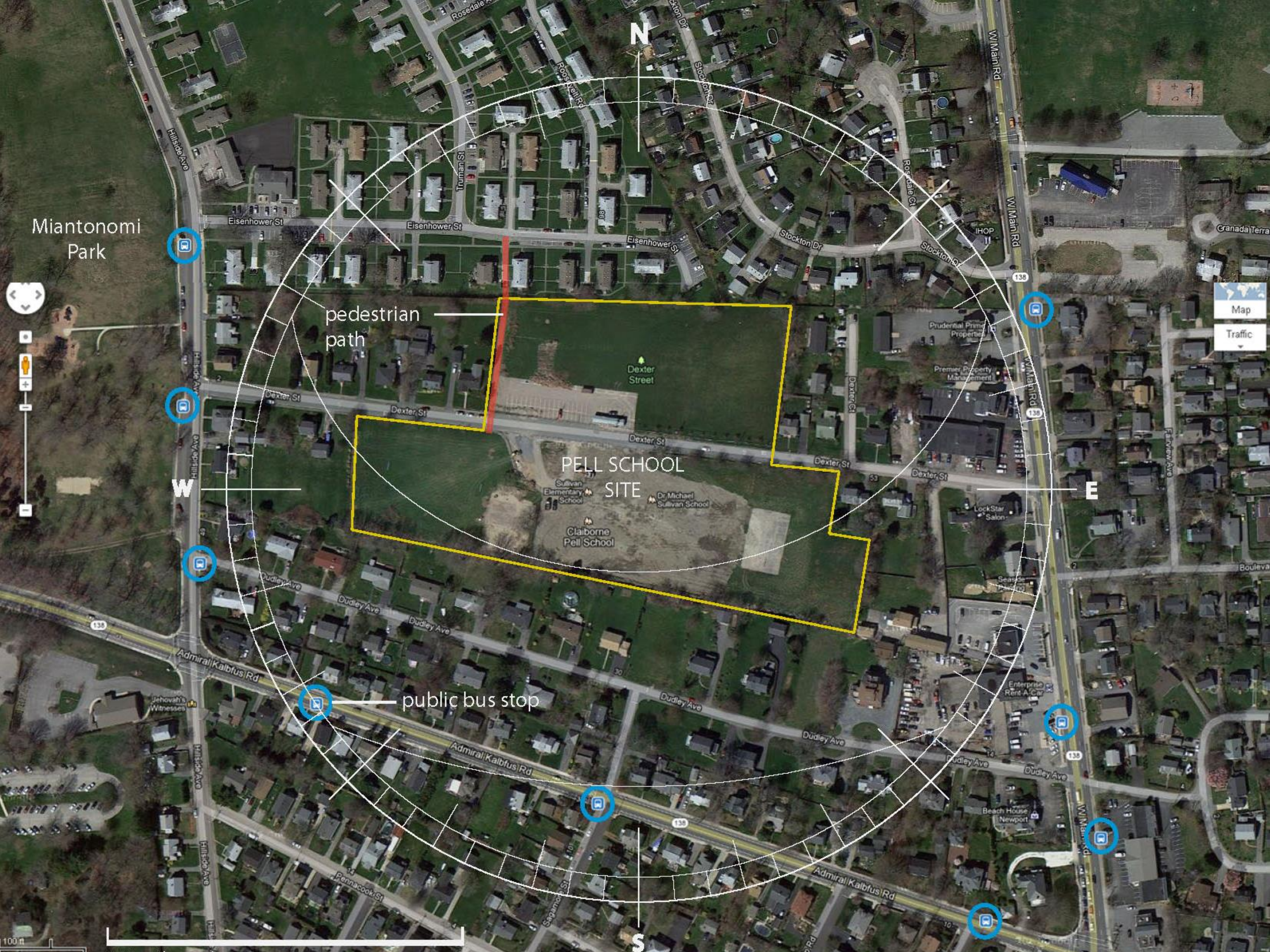


High Performance Schools Case Study: Claiborne Pell School

Newport , RI
Elementary Schools Consolidation

- District wide budget challenges
- Plan to merge 4 aging schools into 1 new high performance school
- 4 sites studied; only 1 was big enough




N
S
E
W
Miantonomi Park
pedestrian path
PELL SCHOOL SITE
public bus stop
Eisenhower St
Dexter St
Dudley Ave
Admiral Kalbfus Rd
Hillside Ave
W Main Rd
Stockton Dr
Truman St
Dexter Ct
Dexter Street
Claiborne Pell School
Dr Michael Sullivan School
Sullivan Elementary School
IHOP
Prudential Prime Properties
Premier Property Management
Enterprise Rent-A-Car
Beach House Newport
LockStar Salon
Jehovah's Witnesses
Pennacook St
Sagamore St
Fairview Ave
Granada Terra
Map
Traffic

Project Scope

- 880 seat, 105,000sf elementary school
- Lower ES for PK to 1 and Upper ES for grades 2-4
- Shared library, cafeteria, and gym
- Air Conditioning to address humid May and Sept.
- Full “scratch cooking” kitchen for cafeteria

Project Goals

- Fulfill educational objectives
- Low maintenance cost
- Low operation cost and low energy cost
- Low potable water use
- Required to meet ANSI 12.60 Classroom Acoustics Standard
- Required to be NE-CHPS certified
- Must work within the project budget
- Maximize incentives from state and utilities

RI High Performance Schools Incentives

Through NE-CHPS….

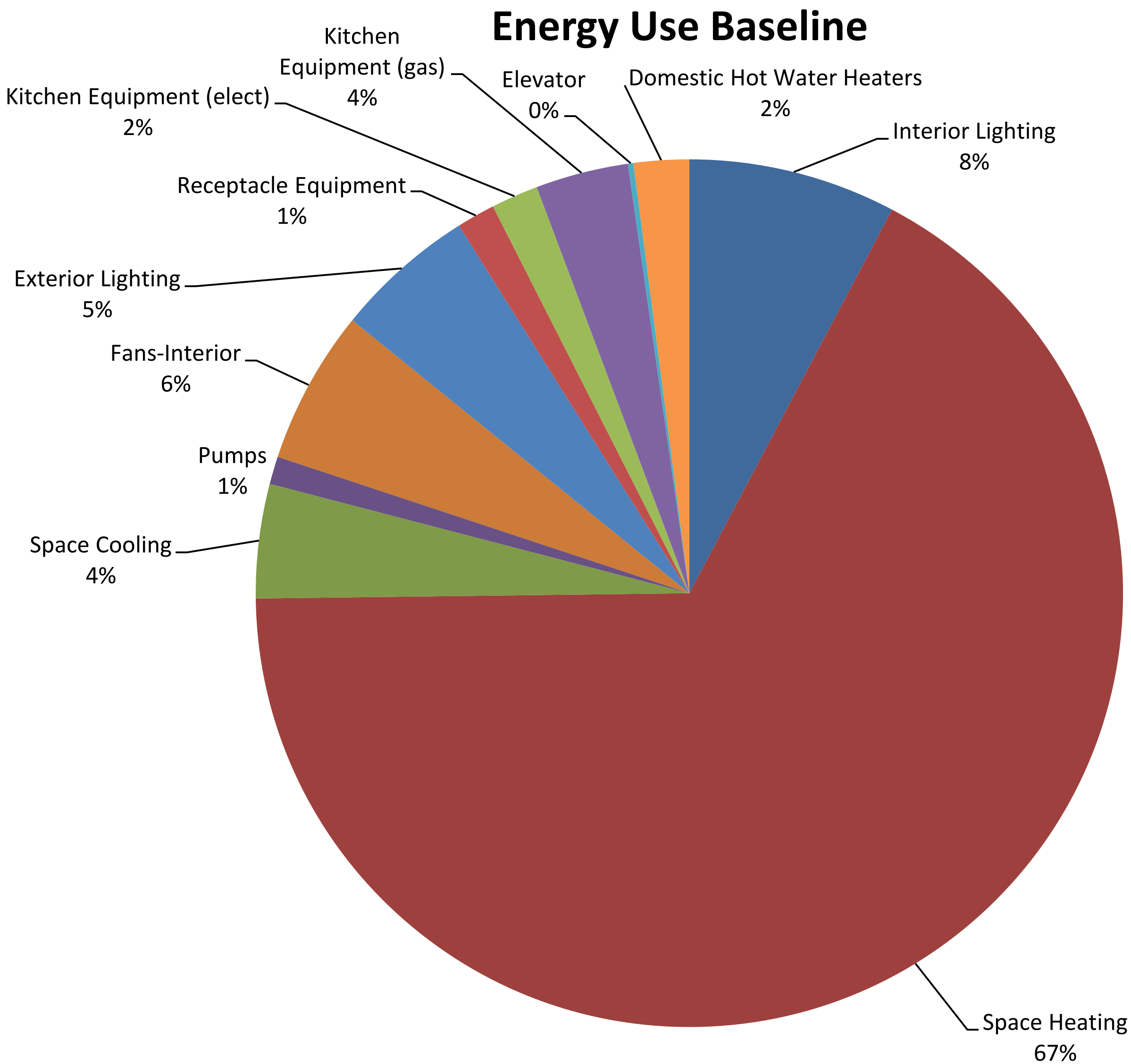
EE EC 1A	Demonstrate superior energy performance – 30% reduction	**Incentive Points:** Eligible for 2% additional reimbursement funds	= $ 600,000
EE EC 1B	Demonstrate superior energy performance – 40% reduction	**Incentive Points:** Eligible for 3% additional reimbursement funds	= $ 900,000
EE EC 1C	Demonstrate superior energy performance – 50% reduction	**Incentive Points:** Eligible for 4% additional reimbursement funds	= $1,200,000

Benefits of HP Buildings on Learning

Studies have found…

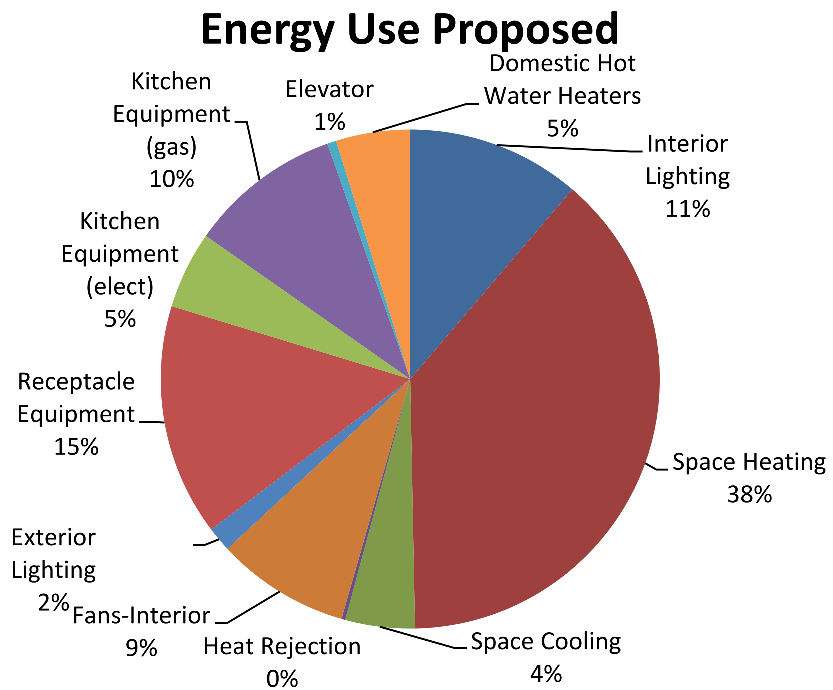
- asthma is the leading cause of student absenteeism due to a chronic illness
- increased indoor CO2 levels decrease students performance on tests
- levels of classroom noise linked to academic achievement; 15% of students have hearing problems
- students in classrooms with the most daylight showed a 21% improvement in learning rates compared to students in classrooms with the least daylight
- 5% to 15% better test scores for students in buildings with better indoor environmental conditions

Where does the energy go?

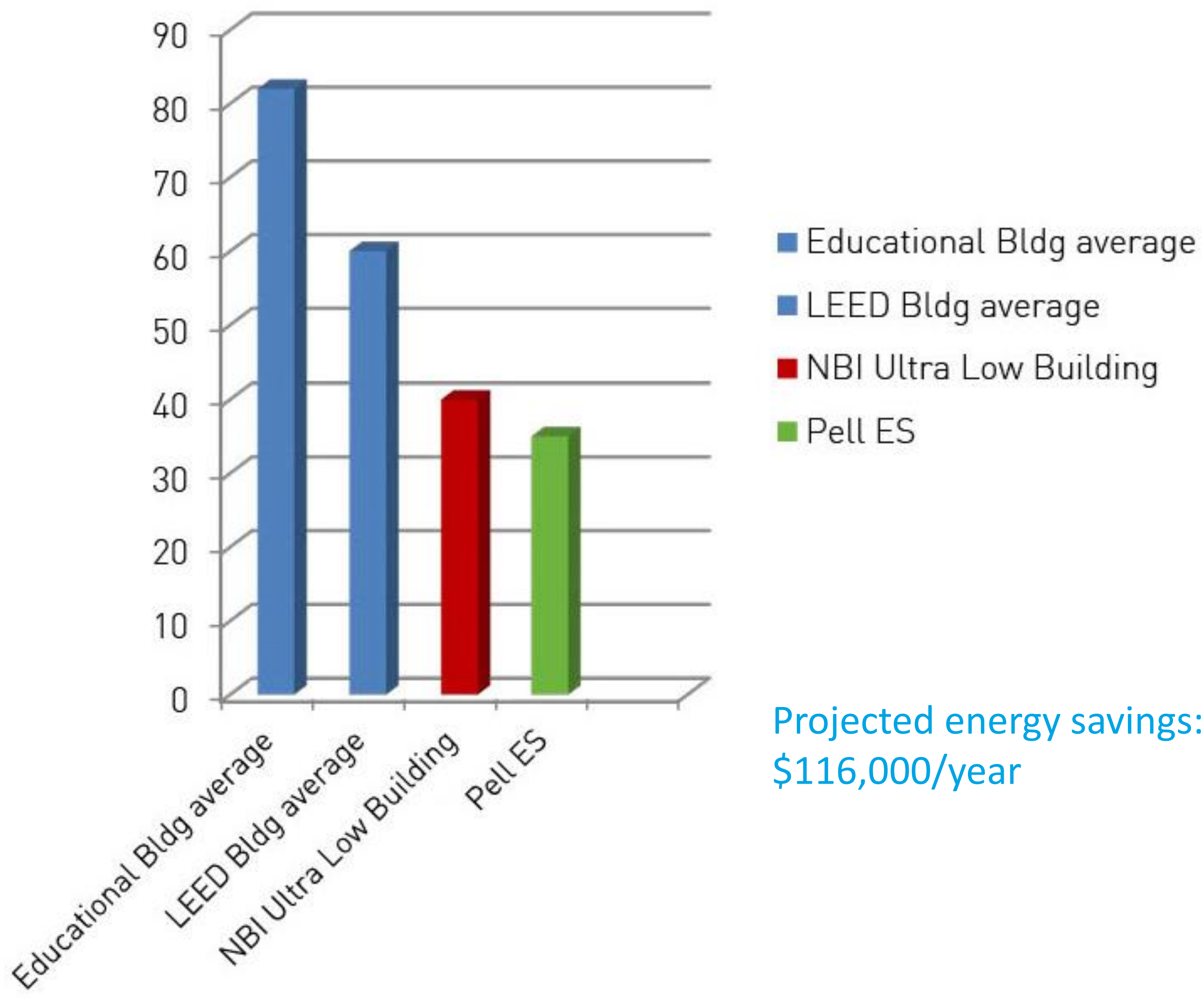


Total annual energy use: 10,437,407 kbtu

Where we ended up

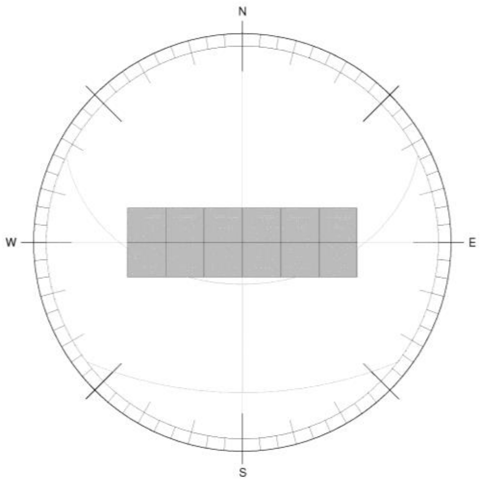


Total annual energy use: 3,655,645 kbtu

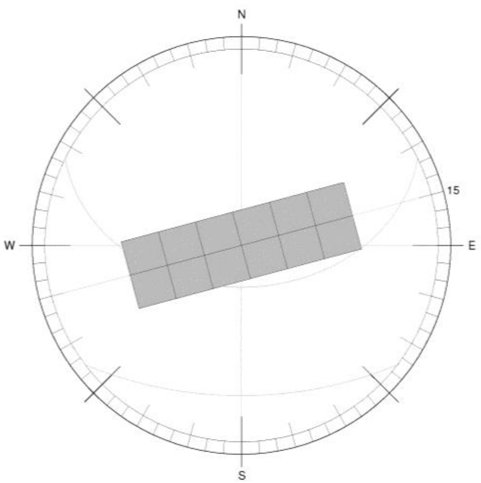


Projected energy savings:
$116,000/year

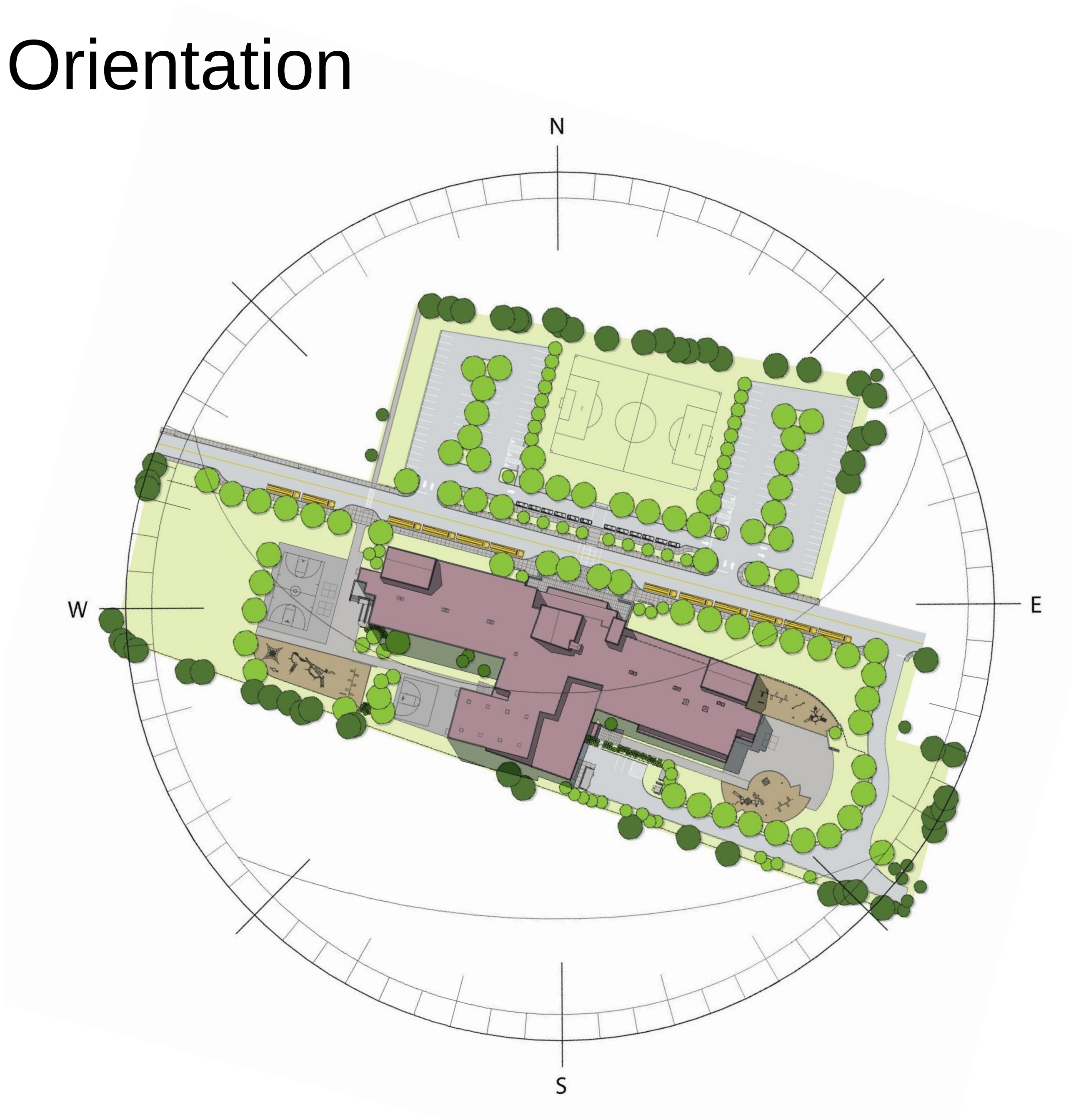
Strategies: Orientation



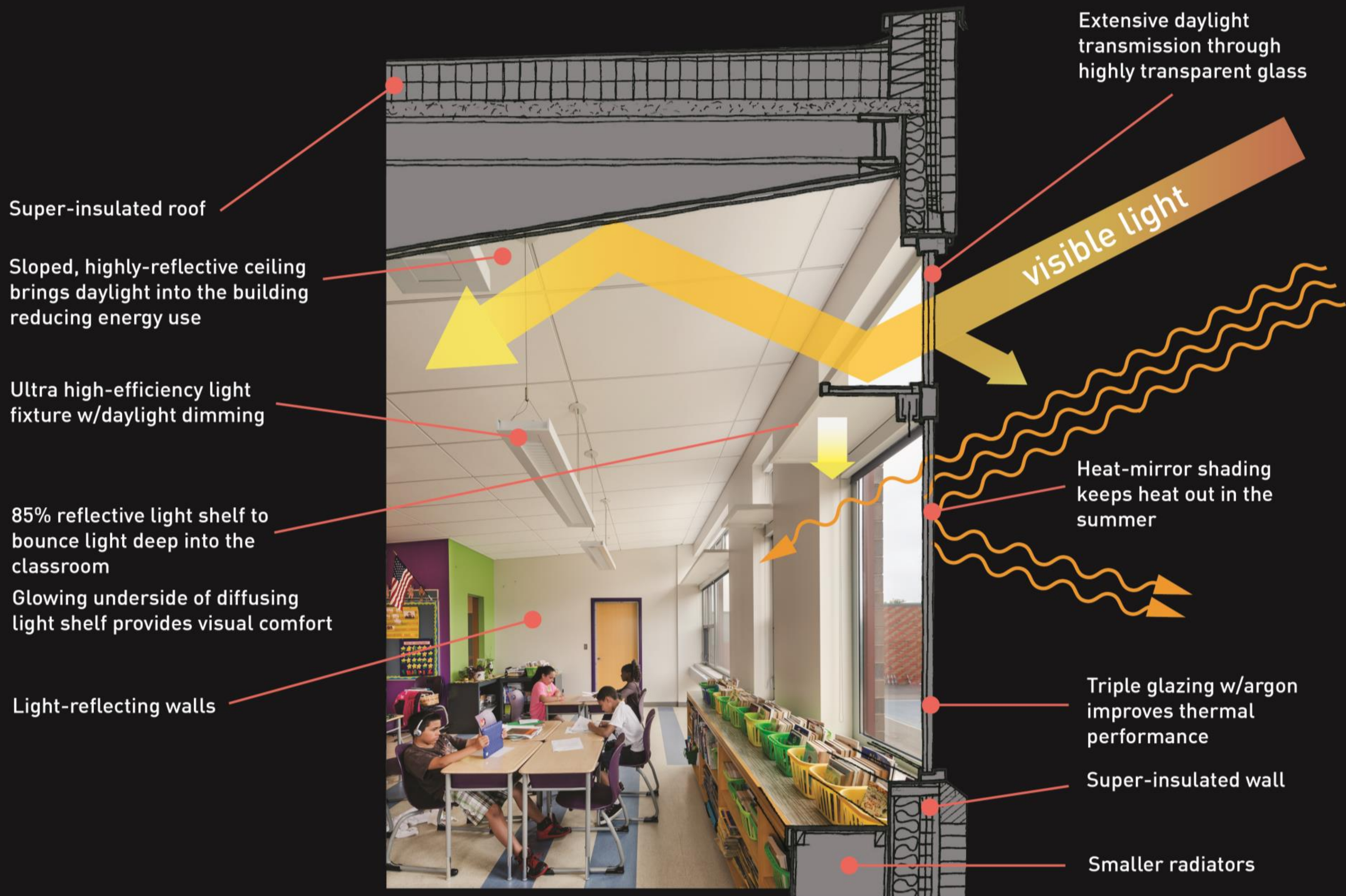
vs.



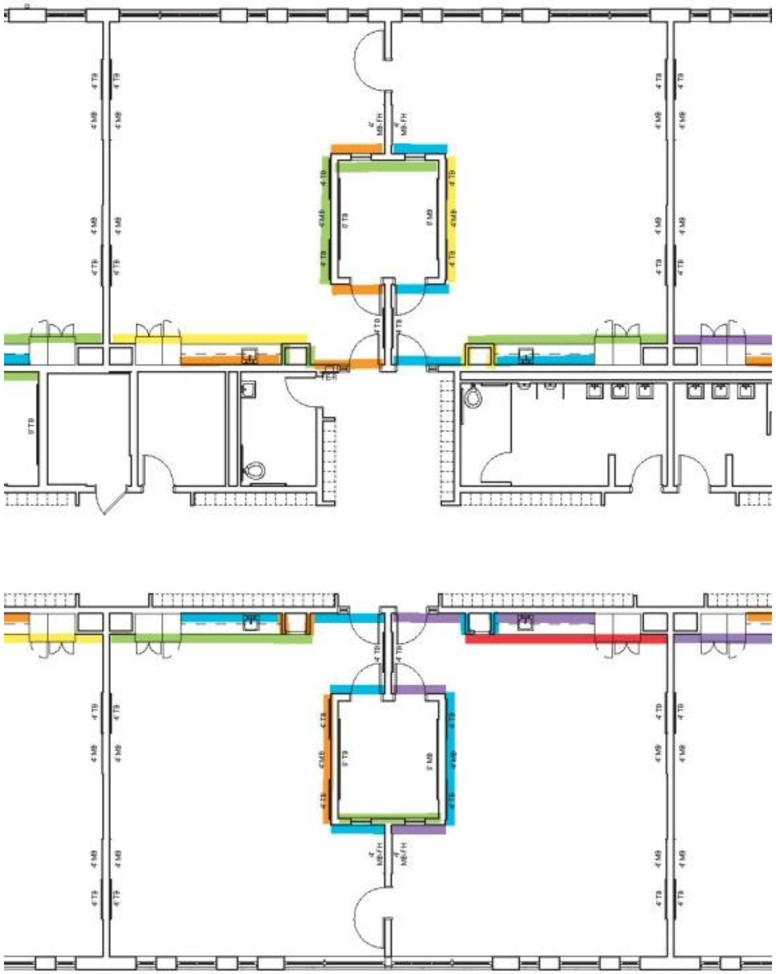
Energy Use Delta = 0.6%



Strategies: Integrated Classroom Design



Light Reflectance



Sherwin Williams Paint Key

Typical Wall Color - SW7035 Aesthetic White — LRV 74

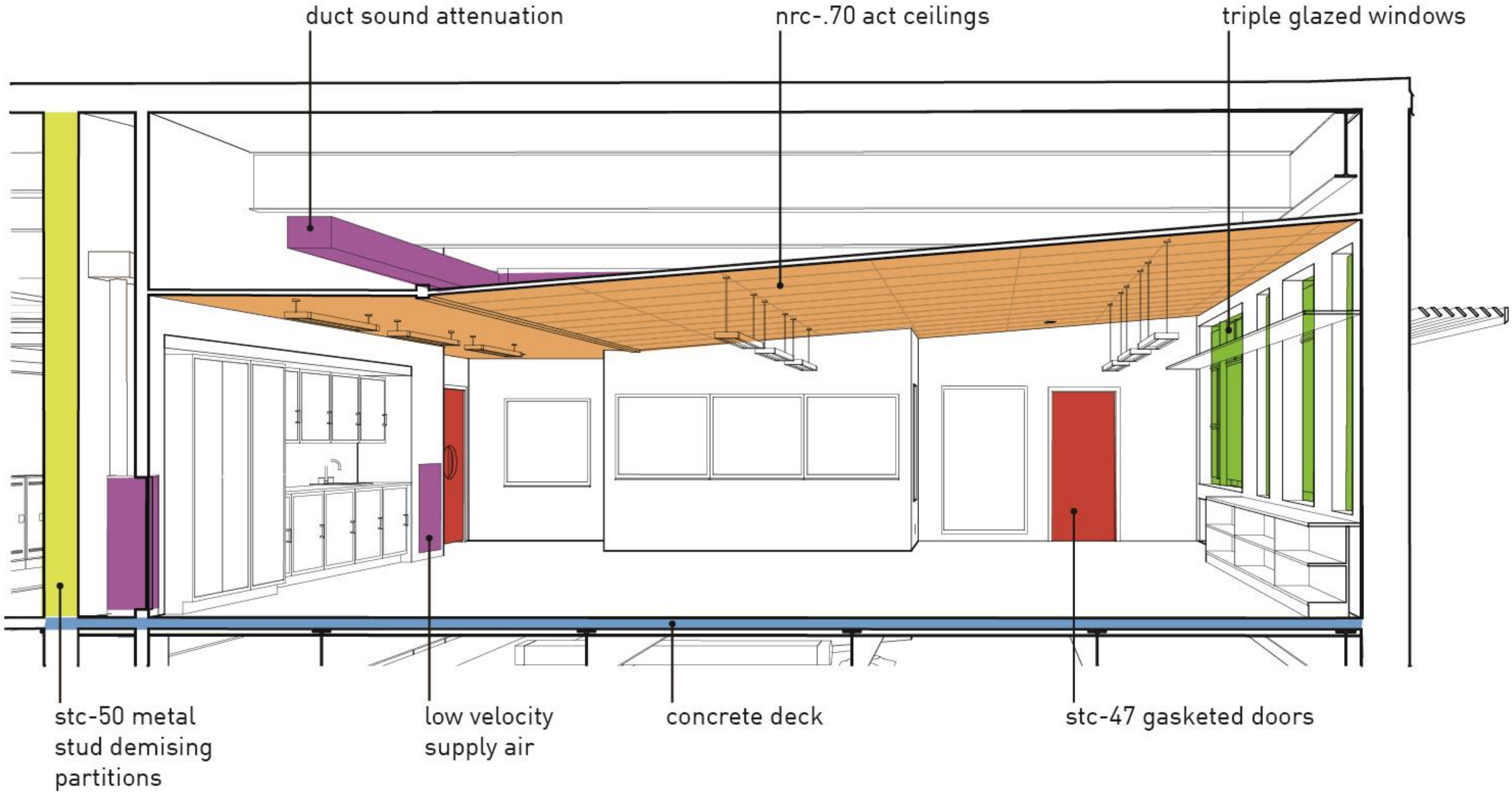
Hollow Metal Frames - SW6559 Concord Grape

Accent Wall Colors

- SW6649 Tango — LRV 34
- SW6950 Calypso — LRV 35
- SW6897 Sundance — LRV 63
- SW6717 Lime Rickey — LRV 45
- SW6831 Clematis — LRV 16
- SW6593 Coral Bells — LRV 16

Ceiling Tiles — LRV 89

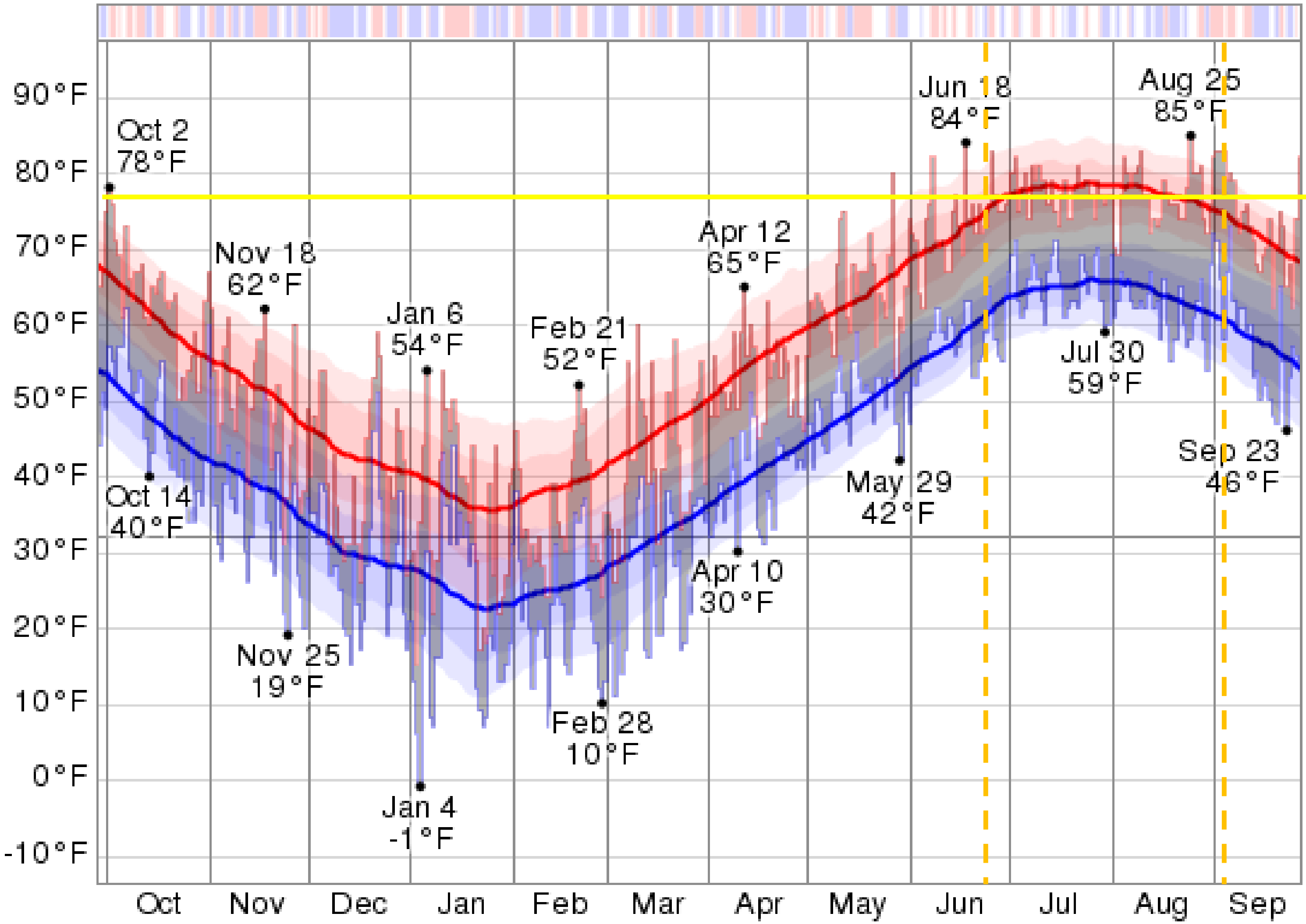
Classroom Acoustics



Strategies: HVAC System Choice

- Code Ventilation Requirement: 15 CFM/occupant
- Climate Factors, Temperature & Humidity
- What is comfortable? Do we really need AC?
- HVAC system options
- How to get client to buy into the best option?
- First Cost vs. Life Cycle Cost
- Displacement Ventilation

Newport Weather in the past 12 months



Newport historical RH in shoulder months

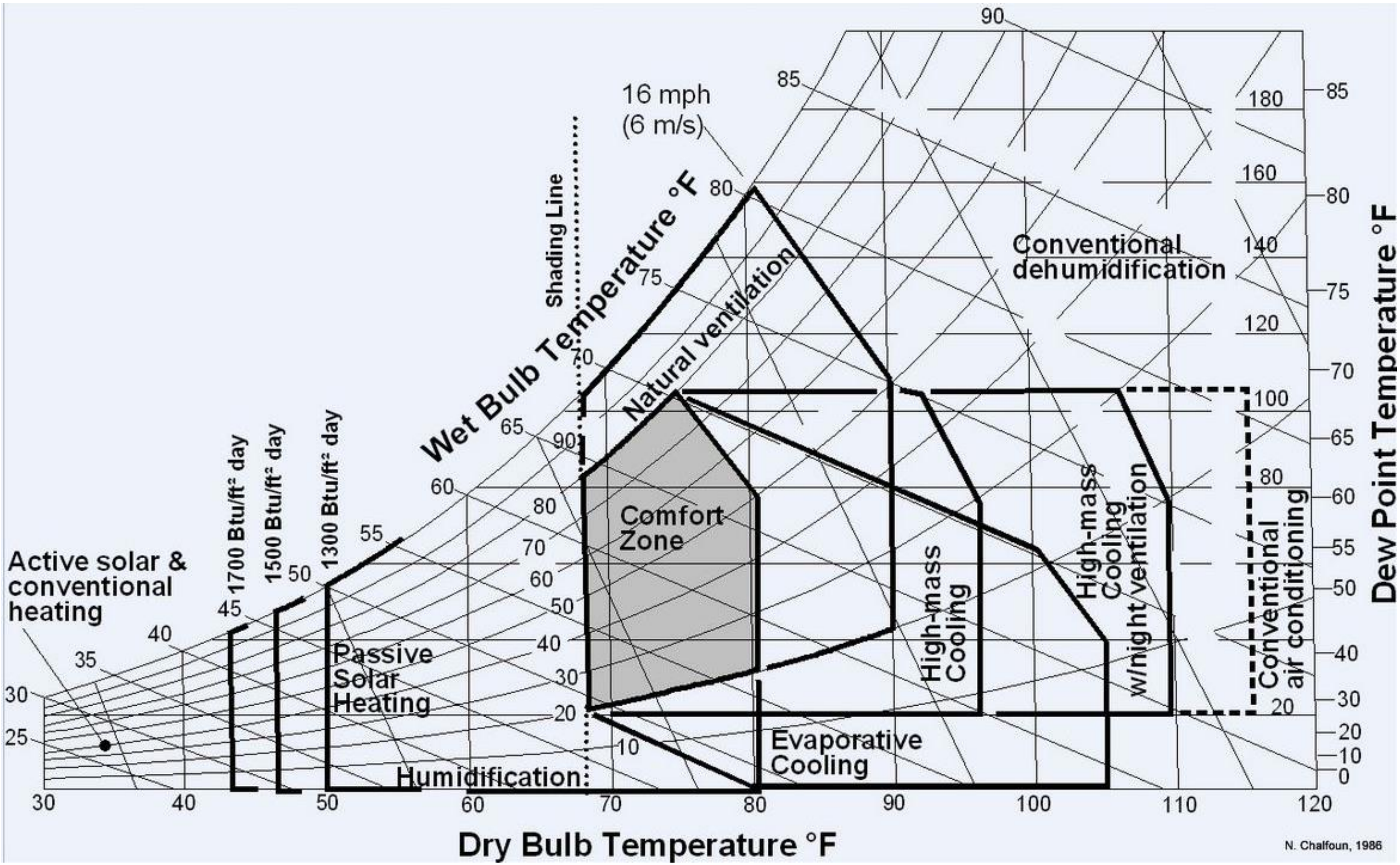
May Relative Humidity

	Max RH% Low		Minimum Humidity Low		Minimum Humidity High		Mean Humidity Avg	Mean Humidity High		Mean Humidity Low		
May 1	45%	1952	19%	2007	93%	2014	66.5%	97%	2014	34%	1952	May 1
	45%	1951										
May 2	48%	1957	17%	1951	89%	1998	68.6%	95%	1998	34%	1957	May 2
May 3	49%	1957	**13%**	1963	94%	2004	68.5%	97%	2004	39%	1963	May 3
	49%	1952								39%	1963	
										39%	1952	
										39%	1951	
May 4	54%	1967	16%	1980	92%	2012	66.8%	96%	2012	40%	1952	May 4
					92%	1999		96%	1999			
May 5	61%	1952	17%	1969	89%	2012	68.4%	95%	1998	43%	1952	May 5
					89%	1998						
May 6	52%	1979	20%	2001	93%	1998	70.5%	97%	1998	41%	1982	May 6
			20%	1995								
May 7	48%	1995	**13%**	1995	93%	2009	66.7%	96%	1998	31%	1995	May 7
								96%	1961			
May 8	**33%**	1950	15%	1950	88%	1954	68.4%	94%	1954	**24%**	1950	May 8
May 9	53%	1957	**13%**	1962	94%	2012	71.5%	97%	1998	36%	1957	May 9
					94%	1998						
May 10	43%	1962	14%	1962	95%	1998	69.4%	98%	1998	29%	1962	May 10
May 11	55%	1966	22%	2001	**97%**	1989	69.2%	**99%**	1989	40%	1966	May 11
May 12	55%	1950	22%	2005	90%	2006	70.2%	95%	2006	43%	1977	May 12
May 13	55%	1967	20%	2007	94%	1979	70.3%	97%	1979	41%	1977	May 13
			20%	1977								
May 14	52%	1951	18%	1994	93%	2006	70.4%	97%	2006	36%	1994	May 14
					93%	1979		97%	1979			
May 15	59%	2000	25%	1994	94%	1953	71.7%	96%	1953	46%	2000	May 15
	Max RH% Low		**Minimum RH% Low**		**High**		**Mean RH% Avg**	**High**		**Low**		
May 16	61%	1960	21%	1987	94%	1961	73.2%	97%	1961	44%	1987	May 16
May 17	54%	1977	22%	1993	94%	1990	70.9%	97%	1990	44%	1977	May 17
May 18	63%	1981	25%	1983	91%	2004	74.4%	96%	2004	45%	1981	May 18
			25%	1955								
May 19	66%	1955	23%	2003	95%	1988	74.3%	98%	1988	48%	1955	May 19
May 20	68%	1981	24%	1981	90%	1972	74.5%	95%	1969	46%	1981	May 20
					90%	1969						
May 21	60%	1967	14%	1992	96%	1954	72.6%	98%	1954	45%	1992	May 21
		1900		1900						45%	1967	
May 22	66%	1998	22%	1992	93%	2012	72.0%	97%	1986	46%	1978	May 22
	66%	1978			93%	1986						
	66%	1982										
May 23	55%	1971	23%	1971	90%	2013	71.7%	95%	2013	39%	1971	May 23
					0%	2003		95%	2003			
May 24	62%	1965	**13%**	1981	95%	1979	73.0%	98%	1979	41%	1981	May 24
May 25	57%	1957	24%	1981	94%	1979	72.9%	97%	1979	41%	1957	May 25
May 26	51%	1980	24%	2007	88%	2011	72.3%	94%	2011	43%	1980	May 26
			24%	1954								
May 27	54%	1954	25%	1980	85%	1974	71.0%	92%	2002	42%	1954	May 27
								92%	1974			
May 28	58%	1952	23%	1980	93%	2004	71.6%	97%	2004	45%	1952	May 28
May 29	60%	1975	28%	1989	90%	2009	73.3%	94%	2009	47%	1989	May 29
			28%	1956				94%	2002	47%	1975	
								94%	1981			
May 30	64%	1993	24%	1993	89%	1950	73.5%	94%	2002	44%	1993	May 30
			24%	1954				94%	1950			
May 31	43%	1954	23%	1954	95%	1984	73.9%	98%	1984	33%	1954	May 31
	Max RH% Low		**Minimum RH% Low**		**High**		**Mean RH% Avg**	**High**		**Low**		

September Relative Humidity

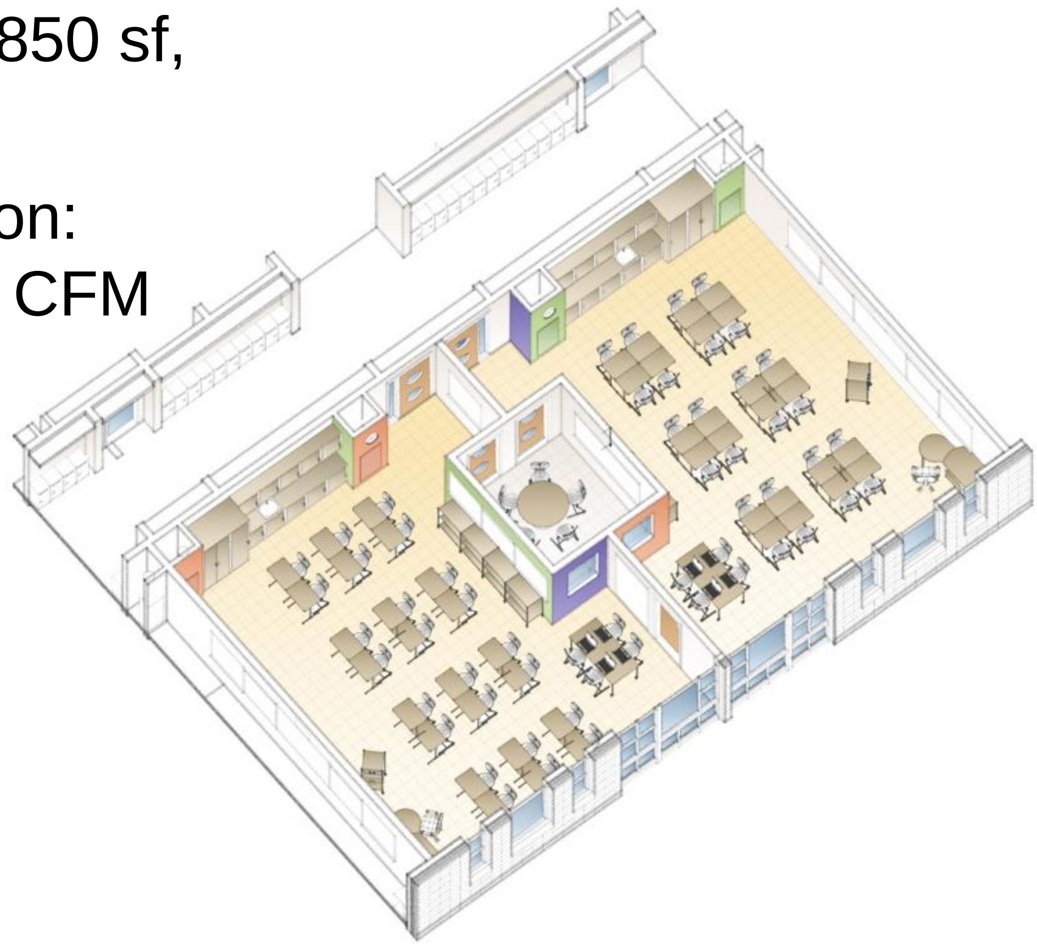
	Max RH% Low		Minimum RH% Low		Minimum RH% High		Mean RH% Avg	Mean RH% High		Mean RH% Low		
Sep 1	63%	1953	29%	1963	93%	2013	73.9%	96%	2013	48%	1953	Sep 1
Sep 2	75%	1984	30%	1960	93%	1976	75.2%	97%	1976	55%	1970	Sep 2
Sep 3	71%	1953	33%	1960	95%	1986	76.2%	98%	1986	54%	1960	Sep 3
Sep 4	72%	1983	34%	2007	93%	2003	75.3%	97%	2003	59%	1983	Sep 4
Sep 5	78%	1998	32%	2007	92%	1991	74.0%	96%	1991	58%	1964	Sep 5
Sep 6	73%	1970	36%	2002	93%	2008	75.3%	96%	2008	58%	1984	Sep 6
										58%	1976	
Sep 7	71%	1952	30%	1980	94%	2011	74.5%	96%	2011	58%	1967	Sep 7
Sep 8	60%	1983	30%	1980	96%	1993	75.2%	98%	1993	48%	1983	Sep 8
Sep 9	69%	1980	29%	1957	90%	1999	75.3%	95%	1999	52%	1980	Sep 9
Sep 10	77%	1975	25%	1980	93%	1999	74.3%	97%	1999	54%	1953	Sep 10
Sep 11	74%	1988	26%	1980	93%	2007	73.2%	97%	1950	50%	1980	Sep 11
	74%	1980			93%	1950						
Sep 12	74%	2002	**23%**	2004	92%	2009	72.3%	94%	2009	55%	2002	Sep 12
	74%	1991										
Sep 13	68%	1955	34%	1991	93%	1987	74.5%	97%	1987	52%	1955	Sep 13
Sep 14	73%	1953	32%	1959	96%	2008	77.7%	97%	2008	55%	1959	Sep 14
Sep 15	73%	1962	34%	1983	91%	2006	77.3%	95%	2006	54%	1962	Sep 15
					91%	1970						
	Max RH% Low		**Minimum RH% Low**		**High**		**Mean RH% Avg**	**High**		**Low**		
Sep 16	81%	2011	34%	1984	95%	2004	75.7%	98%	2004	59%	1984	Sep 16
	81%	1979	34%	1961								
	81%	1964										
Sep 17	67%	2000	28%	1968	**98%**	1993	76.9%	**99%**	1993	54%	1950	Sep 17
Sep 18	78%	1968	35%	1968	96%	1993	76.8%	98%	1993	57%	1968	Sep 18
Sep 19	78%	1982	33%	1959	96%	1989	76.1%	98%	1989	57%	1982	Sep 19
Sep 20	66%	1993	33%	1993	91%	1988	77.5%	96%	1988	50%	1993	Sep 20
					91%	1987		96%	1987			
Sep 21	67%	1984	34%	1984	93%	1986	77.8%	97%	1986	51%	1984	Sep 21
			34%	1962	93%	1961		97%	1961			
			34%	1956								
Sep 22	78%	1955	34%	1955	91%	2011	78.3%	95%	2011	56%	1955	Sep 22
Sep 23	60%	1983	38%	1955	96%	2011	75.9%	98%	1994	50%	1983	Sep 23
Sep 24	70%	1950	32%	1963	**98%**	1973	73.4%	**99%**	1973	55%	1988	Sep 24
Sep 25	74%	1964	29%	1963	93%	2001	74.6%	97%	2001	55%	1950	Sep 25
					93%	1961		97%	1961			
Sep 26	74%	1987	24%	1957	93%	1975	76.5%	96%	1975	53%	1951	Sep 26
Sep 27	**59%**	1957	26%	1957	97%	1993	76.7%	99%	1993	43%	1957	Sep 27
Sep 28	**59%**	1957	24%	1957	96%	2004	75.1%	98%	2004	**42%**	1957	Sep 28
Sep 29	68%	1981	29%	1957	92%	2011	74.8%	95%	2012	49%	1957	Sep 29
Sep 30	67%	1981	25%	1981	93%	2014	74.6%	95%	2014	46%	1981	Sep 30
	Max RH% Low		**Minimum RH% Low**		**High**		**Mean RH% Avg**	**High**		**Low**		

Comfort Zone

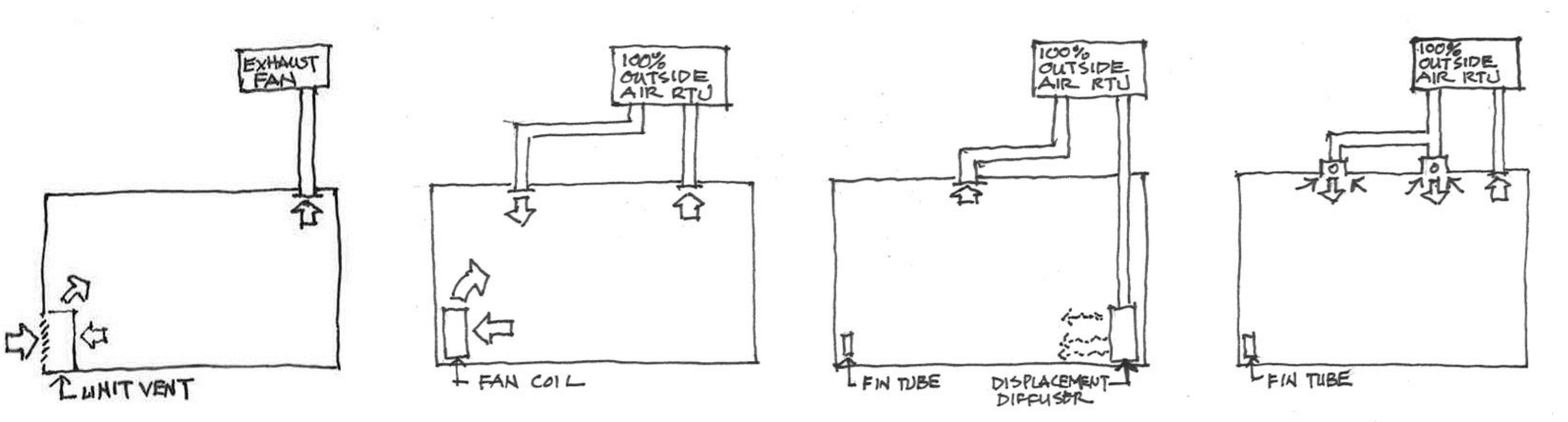


Ventilation Required by Code

- Fresh Air Requirement for Schools: 15 CFM/occupant
- Typical classroom: 850 sf, up to 30 occupants
- Classroom ventilation:
  15 CFM x 30 = 450 CFM



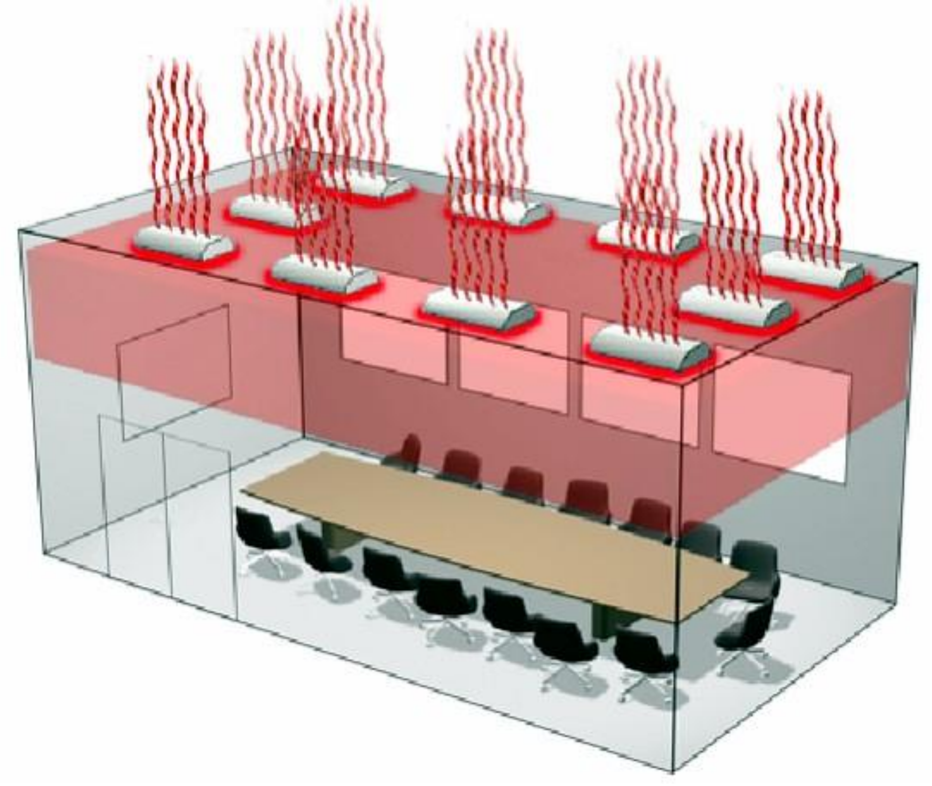
HVAC System Life Cycle Cost Analysis



	Unit Ventilator w/ AC	Fan Coil w/ AC	Displacement Vent. w/ Dehumidification	Induction w/ AC
Noise Level	- - -	- -	+ + +	+ +
Indoor Air Quality	O	+ +	+ + +	+ +
Capital Cost	$ $	$ $ $	$	$$
Maintenance	$ $ $	$ $ $ $	$	$$
Energy Use	$ $ $ $	$ $ $	$	$$
Life Cycle Cost	$ $ $ $	$ $ $	$	$$

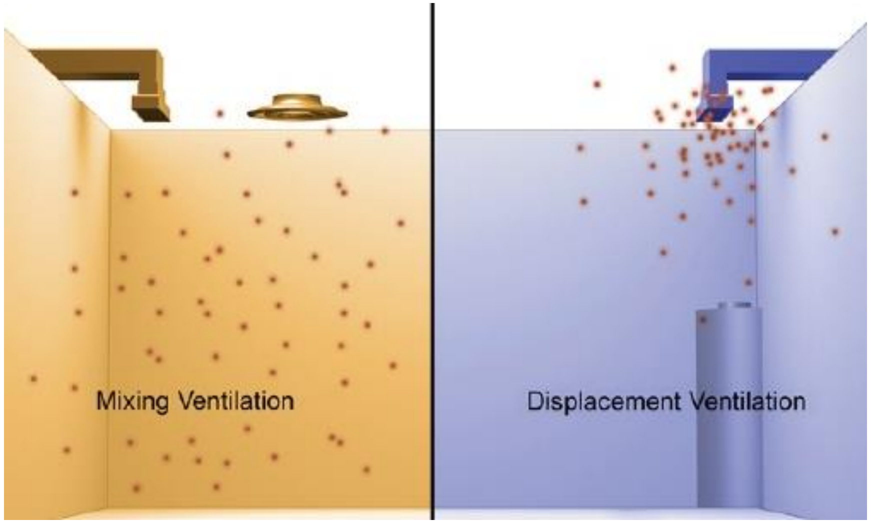
Displacement Ventilation Physics

- Occupied zone floor to 5’ above floor
- Stratified zone above occupied zone
- Allowing heat to rise to ceiling reduces heat gain in occupied zone and reduces air flow
- Key is to establish comfort in occupied zone



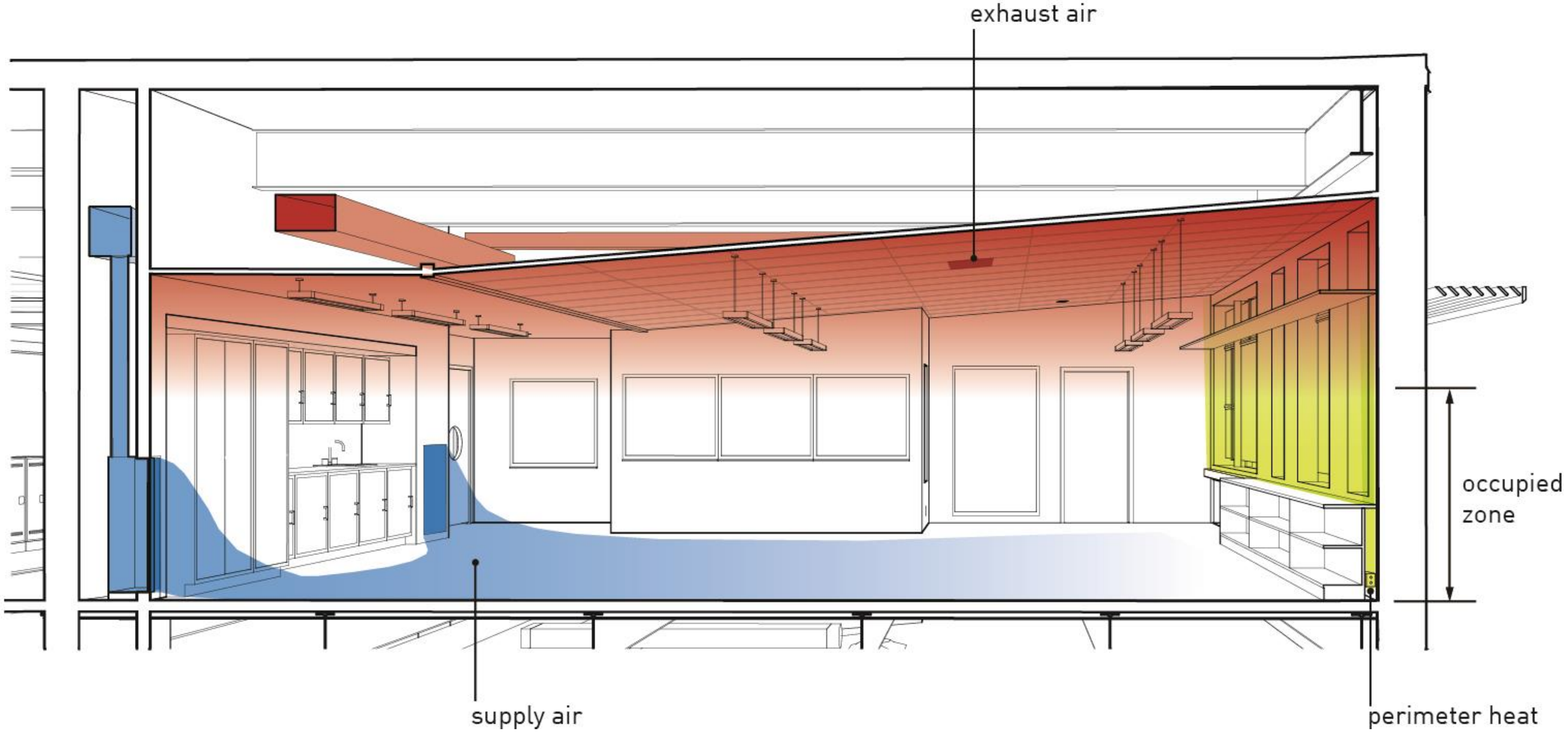
Ventilation Effectiveness

- Increased ventilation effectiveness for displacement ventilation system reduces ventilation rate requirements compared to mixed air overhead systems
- Removal of airborne contaminants from a room



Mixed Systems DV Systems

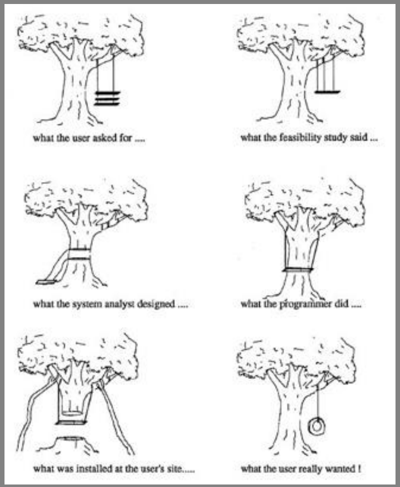
Displacement Ventilation in Classrooms



PAUL W. CROWLEY EAST BAY MET CENTER

Building Better Performance Through Commissioning

Commissioning Overview



Commissioning Process: A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements.

ASHRAE Guideline 0 - 2005


COMMISSIONING PROCESS
CONSTRUCTION PHASE
STEPHEN TURNER INC.
Building Better Performance
STI performs parallel submittal reviews
ALL COMPONENTS ON THE COMMISSIONED SYSTEMS LIST
TAB PLAN
BAS SEQUENCE OF OPERATION
SUBMITTALS
Contractors provide submittals
STI collects checklists & tracks issues
DELIVERY
EQUIPMENT SET
MECHANICAL
ELECTRICAL
PLUMBING
CONTROLS
PRE-FUNCTIONAL CHECKLISTS
Contractors complete checklists CM/GC collects + QCs
STI finalizes test plans and schedules testing based on work progress
CONTRACTOR START-UP
FACTORY START-UP
TEST, ADJUST & BALANCE
CONTROLS
BAS POINT TO POINT
SEQUENCE VERIFICATION
START-UP
Contractors finalize installation
STI leads component, system, and inter-system testing
COMPONENT
SYSTEM
INTER-SYSTEM
FUNCTIONAL PERFORMANCE TESTING
Contractors participate in functional performance testing
STI reviews turnover activities, and tunes building system
O&MS
AS-BUILT
TRAINING
TURNOVER
Contractors fulfill turnover requirements

Project Overview

- Located in Newport, Rhode Island
- An Individual Learning High School
- 20,400 s.f. (including balconies)
- 35 kBtu/s.f./yr Predicted Site Energy Use Intensity (EUI)
- Net-zero Energy Ready
- Design/Build Delivery Method

Commissioned Systems

- Heating Hot Water Systems
- Energy Recovery Unit
- Geo-Exchange System & Ground Source Heat Pumps
- Solar Thermal Domestic Hot Water System
- Rainwater Harvesting System
- Energy Metering & Dashboard

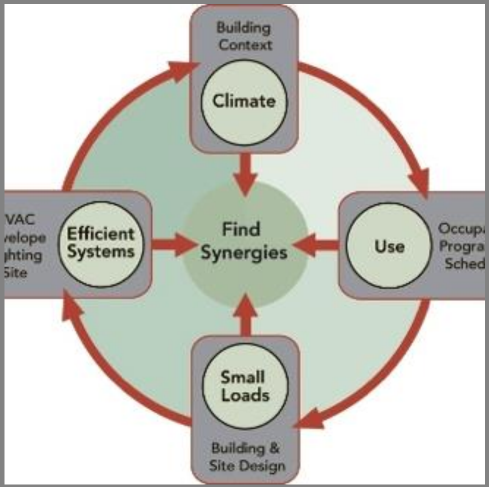
Owner's Project Requirements (OPR)

- Conformance with the Rhode Island School Construction Regulations & NE-CHPS v2.0
- Net-zero Energy Ready (Site EUI of 35 kBtu/s.f./yr.)
- School as a teaching tool
  - Students
  - Staff
  - Future school project teams

Teachable Moments

- Goal Oriented Design
- Comprehensive Functional Performance Testing
- Predicted vs. Actual Performance
- School as a Teaching Tool

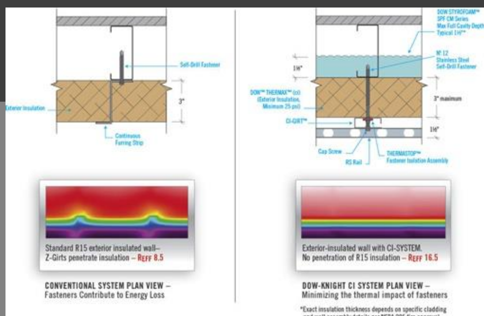
Goal Oriented Design

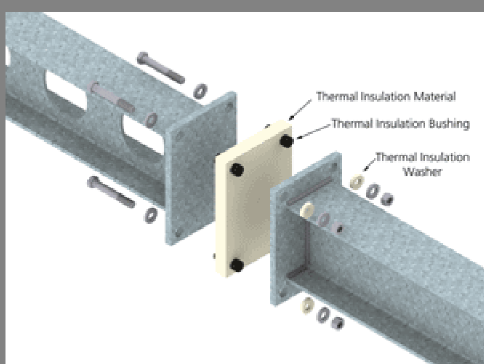


- Setting early performance goals facilitates an integrated design process and has the entire team aiming for the same goal. Performance targets provide the predictability necessary to allow design teams to maximize the tradeoffs between systems.

Goal Oriented Design
Net-Zero Ready

- Setting an overall energy use intensity goal rather than a percent reduction from a baseline supports a more holistic approach to project design. It encourages analysis of passive strategies that may not always be recognized in a reduction from baseline analysis strategy.
- The project is photovoltaic ready and has a plan in place to provide the PV necessary to be net-zero based on predicted energy use.





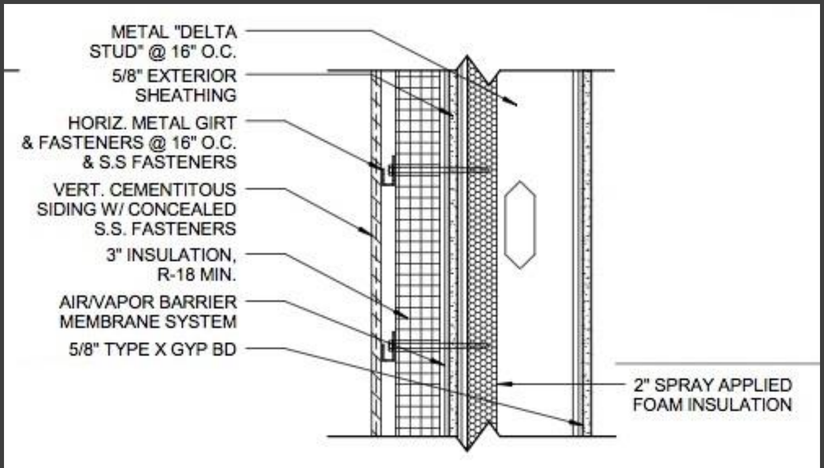
Goal Oriented Design
Building Enclosure

- OPR = Support Net-zero & 35 kBtu/s.f./yr. EUI
- BOD = Rain screen w/ R-25ci (≈U-0.055)*
- Challenges
  - NFPA 285
  - Thermal Bridging
  - NE-CHPS Material Requirements
- Solution = Rain screen R-14 + R-18ci (≈U-0.033)**

* Overall system performance downgraded due to thermal bridging
** Overall system performance maintained due to reduction of thermal bridging of rain screen support and structural steel framing.

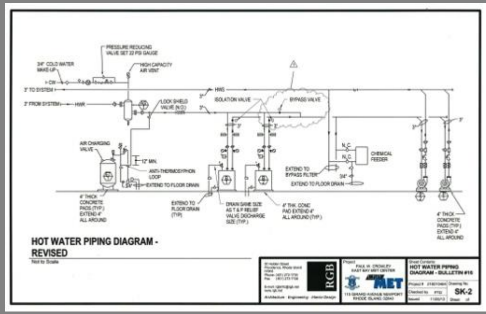
Goal Oriented Design – Building Enclosure

Opaque Wall – Basis of Design (U≈0.055)



Opaque Wall – As-Built (U≈0.033)

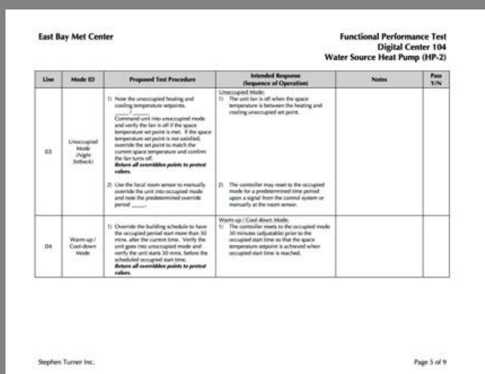
Comprehensive Functional Performance Testing



- Correct inputs and outputs are critical to proper system operation but…
- Most issues identified during functional performance testing were found during testing of sequences of operation
  - Heating hot water system temperature
  - Pump rotation
  - Ground source heat pump integration

STEPHEN TURNER INC.
Building Better Performance

Comprehensive Functional Performance Testing


East Bay Met Center

Functional Performance Test
Digital Center 104
Water Source Heat Pump (HP-2)

Line	Mode ID	Proposed Test Procedure	Intended Response (Sequence of Operation)	Notes	Pass Y/N
03	Unoccupied Mode (Night Setback)	1) Note the unoccupied heating and cooling temperature setpoints. ____ / ____ Command unit into unoccupied mode and verify the fan is off if the space temperature set point is met. If the space temperature set point is not satisfied, override the set point to match the current space temperature and confirm the fan turns off. ***Return all overridden points to pretest values.*** 2) Use the local room sensor to manually override the unit into occupied mode and note the predetermined override period ____.	Unoccupied Mode: 1) The unit fan is off when the space temperature is between the heating and cooling unoccupied set point. 2) The controller may reset to the occupied mode for a predetermined time period upon a signal from the control system or manually at the room sensor.		
04	Warm-up / Cool-down Mode	1) Override the building schedule to have the occupied period start more than 30 mins. after the current time. Verify the unit goes into unoccupied mode and verify the unit starts 30 mins. before the scheduled occupied start time. ***Return all overridden points to pretest values.***	Warm-up / Cool-down Mode: 1) The controller resets to the occupied mode 30 minutes (adjustable) prior to the occupied start time so that the space temperature setpoint is achieved when occupied start time is reached.		

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- A thorough functional performance test includes:
  - Input verification
  - Output verification
  - Testing of ALL sequences of operation
  - Alarm & safety verification
  - Trend verification
  - Deferred seasonal testing (as required)

Comprehensive Functional Performance Testing

East Bay Met Center

Functional Performance Test
Energy Recovery Unit (ERU-1 & EF-1)

4. Output Device Checks

Verify the actuators or devices listed below have been checked for calibration and position feedback. This is a spot check for calibration to ensure proper systems operation. "In calibration" means observing BAS work station status or value, and verifying this condition at the actuator or controlled device to confirm that BAS output is correct. For items out of calibration or adjustment, make simple adjustments now at the BAS if practical; mechanical repairs are not in scope.

Device or Actuator	Position / Status	Site Observation	Pass Y / N ?
Outside Air Damper	1. Closed		
	2. Open		
ERU Supply Fan Command	1. Start		
	2. Stop		
ERU Supply Fan VFD Output	1. Min Speed	Hz / A / RPM	
	2. 50% Speed	Hz / A / RPM	
	3. Max Speed	Hz / A / RPM	
Exhaust Air Damper	1. Closed		
	2. Open		
ERU Exhaust Fan Command	1. Start		
	2. Stop		
ERU Exhaust Fan VFD Output	1. Min Speed	Hz / A / RPM	
	2. 50% Speed	Hz / A / RPM	
	3. Max Speed	Hz / A / RPM	
Hot Water Control Valve	1. Full Closed		
	2. 50% Open		
	3. Full Open		
Bypass Damper	1. Closed		
	2. Open		
Exhaust Fan 1 Command	1. Start		
	2. Stop		
Exhaust Fan 1 VFD Output	1. Min Speed		
	2. 50% Speed		
	3. Max Speed		

Notes:

Stephen Turner Inc. Page 4 of 12

Input & Output Testing

East Bay Met Center

Functional Performance Test
Energy Recovery Unit (ERU-1 & EF-1)

Line	Mode ID	Proposed Test Procedure	Intended Response (sequence of operation)	Notes	Pass Y / N
01	Occupied Mode	1) Command the unit into occupied mode. 2) Override the outdoor air temperature to be below 65°F and verify the ERU supply and exhaust fans run and EF-1 is off. 3) Override the outdoor air temperature to be above 65°F and verify EF-1 runs and ERU fans are off. 4) Raise the discharge temperature setpoint to 80°F. Lower the discharge temperature setpoint to 65°F. ***Return all overridden points to pretest values.***	Occupied Mode: 1) The building DDC system shall send a start command to the energy recovery unit control system. 2) When outside air temp is below 65°F (adj.), ERU supply and exhaust fan shall be in operation and EF-1 shall be off. 3) When outside air temp is above 65°F (adj.), ERU supply and exhaust fans are off and EF-1 shall run. 4) Hot water control valve shall modulate to maintain unit discharge air temp of 70°F.	Re: Cx Issue C-026	
02	Unoccupied Mode *(Night Setback)*	1) Command the unit into unoccupied mode. Verify the unit turns off and verify the position of all dampers & control valves. 2) While in unoccupied mode, override space temperatures to be 80°F and the outdoor air temperature to 60°F and verify the ERU turns on. While in unoccupied mode, override space temperatures to be 55°F and the outdoor air temperature to 60°F and verify the ERU turns on. ***Return all overridden points to pretest values.***	Unoccupied Mode: 1) The building DDC system shall send a stop command to the energy recovery unit control system. 2) The ERU shall also cool the building with cool "night" air in the summer and warm "day" air in the winter during unoccupied periods. This program shall indicated to the operator that the unit is "ON" in "NIGHT SETBACK" override when a status inquiry is made.		

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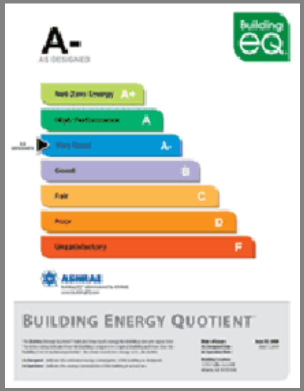
Sequence Testing

Predicted vs. Actual Performance

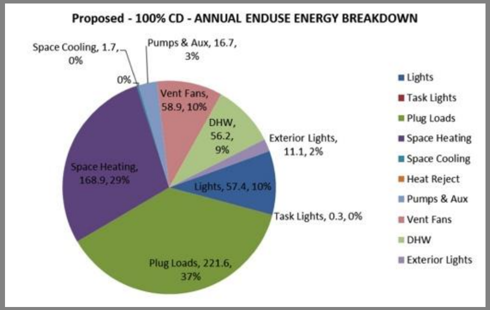


"…to some degree, all energy models are wrong." Primary causes for variance between predicted and actual performance include:

- Mother nature
- Occupant behavior
- Systems operation
- Operator error

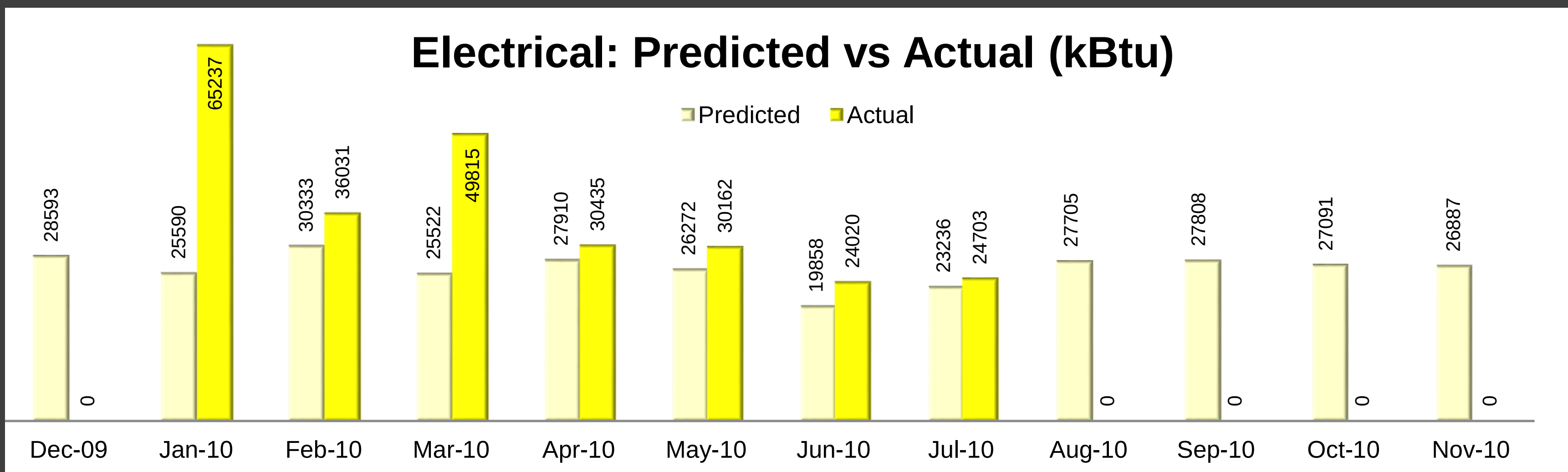
Daniel Overbey, EDC Magazine, August 2014

Predicted vs. Actual Performance



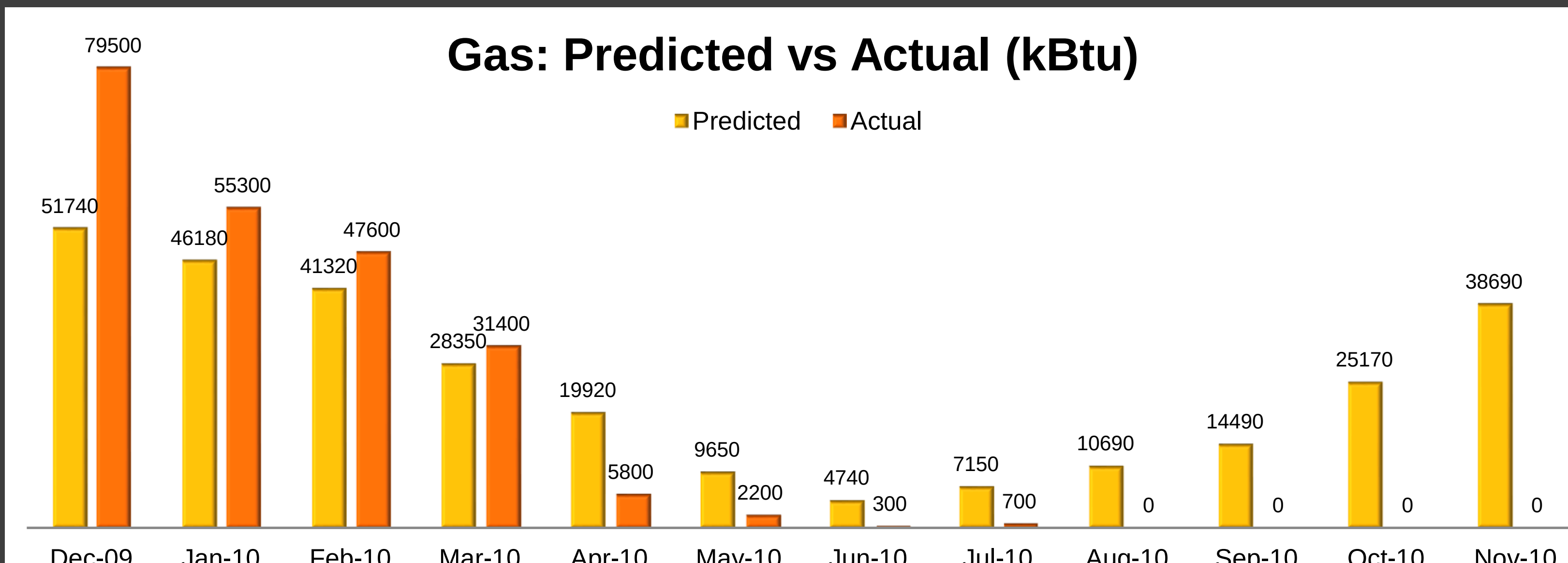
- First year energy use monitoring to date indicates that the East Bay MET Center has used approximately 16% more energy than predicted. Primary causes of higher energy use than predicted are:
  - Operator error
  - Ground source heat pump integration issues
  - Solar thermal system operational issues
  - Occupant behavior

Predicted vs. Actual Performance



Current electricity use is 26% above predicted electricity use

Predicted vs. Actual Performance

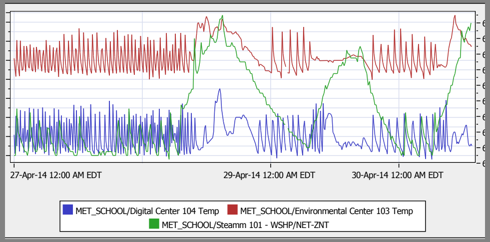


Current natural gas use is 6% above predicted natural gas usage

Predicted vs. Actual Performance
Operator Error

- Vacation and holidays were not programmed into the Building Automation System (BAS) resulting in the building running in occupied mode for multiple days that were not predicted.
- The heating hot water plant was not turned off during summer months as predicted.

Predicted vs. Actual Performance
Systems Operation – Ground Source Heat Pumps



- Ground source heat pumps operate per Original Equipment Manufacturer (OEM) controls and serve the same spaces as field controlled fin tube radiation.
- Trend data indicates that ground source heat pumps are not operating to maintain the unoccupied temperature setpoint.

Predicted vs. Actual Performance
Systems Operation - Solar Thermal

- Operational issues were identified with the 3-way valve during functional performance testing.
- During first year monitoring it was determined that the 3-way valve was not modulating to circulate solar thermal energy to the pre-heat tank due to a faulty panel temperature sensor.
- Proper operation of the solar thermal system is predicted to save 5,860 kWh or approximately 20,000 kBtu per year.

Occupant Behavior

- Spaces designed as workrooms are being used as private offices.
- Space temperature setpoints set above (or below) assumptions used in energy modeling.
- Stuff!! Items that were not intended to be in the building are in the building. (e.g., portable refrigerators, fans, task lights, holiday lights)
- Night cleaning crew results in lighting being on during part of the "unoccupied" period.

School as a Teaching Tool

- Energy dashboard display in building lobby
- Educational stair
- LED lighting is cost competitive
- Systems included as proof of concept for future projects
  - Solar Thermal
  - Geo-exchange with ground source heat pumps

Thank you and Evaluations

This concludes The American Institute of Architects Continuing Education Systems program.

Please take a minute to complete you evaluation of this workshop so we can continue to provide the highest quality education program.

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